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# BAT SPECIES COMPOSITION AND ROOST USE AT WHITE SANDS MISSILE RANGE, NEW MEXICO

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Research Report

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## Introduction

Bats are one of the most unique and diverse orders of mammals in North America. As the primary predator of nocturnal insects, bats have an impact on insect populations, insect activities, and many insect-related ecological processes (such as herbivory, pollination, disease transmission, etc.). These far reaching influences suggest that bats play an important role in ecosystem function, balance, and integrity. Despite their diversity, abundance, and importance in the environment, little is known about their biology, life history, behavior, and habitat requirements. Alerted by the growing number of bats on federal and state lists, biologists and land managers have recognized the need for this information to effectively manage and protect these species. Future land management decisions relating to bats and federal/state status determinations may largely depend on information provided by research on geographic presence/absence, habitat associations, life histories, foraging and roost requirements, and other critical needs and threats.

Of the 26 bat species found in New Mexico, two are federally endangered and thirteen are federal Species of Concern (former Category 2 Candidates). Seventeen bat species (of which 9 are Species of Concern) have been confirmed as present on White Sands Missile Range (WSMR) [Environmental Stewardship Division 1999], but a thorough evaluation of the distribution and relative abundance of these species has not been conducted. Brozka (1991) reported the presence of 11 bat species on WSMR from a minimal netting effort at 6 sites in 1989 and 1990. Bogan (1997) reported 10 bat species captured in the San Andres mountains from 6 nights of netting in the spring and early summer of 1996. Two of Bogan's four net sites were within WSMR boundaries. The amount of time spent and area covered on WSMR in both of these studies were rather limited. Thus the first objective of this field season was to identify and net as many water sources on WSMR as possible for bats throughout summer 1999. The goal of this effort was to contribute to a more comprehensive evaluation of bat species composition, distribution, relative abundance, and reproductive timing on WSMR.

To effectively manage bat habitats and populations, it is also important to understand species'

habitat use and requirements. In the Southwest, surface water is limiting and therefore may influence the distribution of bats across the landscape. However, suitable maternity roosts may be most critical to successful reproduction of bats because they provide a microclimate that facilitates gestation in pregnant females and rapid growth of pups (Humphrey 1975). Knowledge of which structures are used as maternity roosts is essential to effective management of bat habitat and populations. Thus the second objective of this study was initiate a radiotelemetry project to identify types of structures used as maternity roosts by various bat species, especially Species of Concern, on WSMR.

## Methods

### Net Site Identification

In early summer 1999, we searched the Range extensively for water sites that could be netted. The San Andres National Wildlife Refuge was not included in the search area. Good net sites are those that provide a reliable and accessible source of water for bats. Logistically, good net sites are also accessible to field personnel by road. Net sites preferably contain water all summer long (or year-round), have large areas where the surface is not obstructed with vegetation, and are relatively shallow throughout (< 4 ft depth). Potential netting sites were identified by consulting with WSMR biologists, checking water sites on USGS topographic maps, and ground searching along secondary and dirt roads. Most water sites indicated by WSMR biologists were in the northern half of the range.

### Bat Capture

We used bat capture methods outlined in Kunz and Kurta (1988). Bats were captured in mist nets (6, 9, and 12m) set over pools of water. Nets were opened at dusk and were monitored constantly until they were closed around midnight (between 2300 to 0100). For each bat captured, species, sex, age, reproductive status, and time of capture were recorded. For some species, body measurements (weight, forearm length, and ear length) were also recorded. On nights when radiotransmitters were to be applied, a number of reproductive females were retained as candidates for radiotracking. No voucher specimens were kept.

### Roost Identification

Radiotelemetry is a method commonly used to identify structures used by bats as maternity roosts. Although relatively time consuming and expensive, radiotelemetry is a valuable method because it can lead to roosts that would not otherwise be found by targeted ground searches (i.e. checking buildings, caves, mines, etc.). To locate maternity roosts, we applied radiotransmitters to reproductive female bats (preferably federal Species of Concern) and attempted to relocate them in their day roosts on subsequent days. The radiotransmitters weighed from 0.49 to 0.62 g and were manufactured by Holohil Systems Ltd (Woodlawn, Ontario). Radiotransmitters were attached to the bat between the scapulae with surgical glue (Skin Bond ©). After the glue dried (approximately 30 minutes), the bats were released. Day- and night-time, ground-based radiotracking was conducted during the following 7-10 days to locate the radiotagged bats. Radiotransmitter batteries typically last 5-10 days, and signals typically travel from 1/4 mile to 2 miles, depending on terrain and type of roost (e.g. rocks vs. trees). Once a roost was located, general information (roost type, location, characteristics) and GPS locations were recorded.

## Results and Discussion

### Net Site Identification

We checked water status and suitability for mist netting at 25 sites, most of which were in the vicinity or north of RR 6. The site names, locations, descriptions, and water status are reported in Appendix A. Many sites were not indicated on the 1:100,000 USGS topographic maps and hence were found by word of mouth or by ground searches. Twelve sites in habitats ranging from desert scrub to pinyon-juniper were selected for netting (Appendix A). Although a few potential water sites were suggested in the southern half of the range, logistics and time constraints prevented us from visiting and checking them.

### Capture Results

Netting data should always be interpreted with great care. Habitat characteristics (water availability, vegetation structure, roost opportunities, etc.), species characteristics (roost preferences, foraging behavior, flight characteristics, etc.), and other factors determine whether a

bat species is present in an area during a particular season and year. But many additional factors such as the weather, moon phase, researcher skill and experience, and bat behaviors influence whether a species may be successfully mist netted on any given night. Because mist netting results are influenced by so many factors, lack of capture does not necessarily indicate the absence of a species. Despite its biases, mist netting and other similar trapping methods are the only means by which bats can be examined in-hand and positively identified to species. Repeated sampling efforts increase the probability of detecting species. Accordingly, this season's netting results will be interpreted with caution and in light of previous netting data (Brozka 1991, Bogan 1997).

*Analysis by net location*

We mist netted from 9 June to 10 September 99 at the 12 water sites selected. We captured 460 bats of 12 species during 22 nights of netting (Table 1). On 4 of the 22 nights, no bats were captured (Table 1). Most sites were netted twice. The sites with the highest number of captures over 2 nights include Martin Tank (91 bats), Rhodes Spring (84), and Ben Site (61) (Table 2). Capture success was also high at Ridner tank (46 bats), but bat species diversity was low (3 species) and the tank was netted only one night. Sites where a moderate number of bats were captured over 2 nights include Rock House (53), Hardin Tank (49), and Val-Kil (41). The fewest bats were captured at Borrego Spring, Malpais Spring, and Mound Springs. None were captured at Windy and Moya Tanks. Reasons for low capture numbers may include low use by bats, adverse netting conditions (wind, moon, etc.), and high water surface area to net ratio. Although moderate bat activity was observed at Malpais and Mound Springs, relatively few bats were captured, most likely due to the high surface area of water at these sites.

Hardin Tank and Rhodes Spring had the highest bat species diversity (9 species), and Malpais Spring the lowest (2 species) [Table 1]. At Rhodes Spring, Brozka (1991) reported the same nine and one additional species, *Myotis velifer* (Table 2). During our one night of netting at Malpais Springs, we caught one of the 7 species reported by Brozka (1991) [*Tadarida brasiliensis*] and one additional species, *M. ciliolabrum* (Table 2). In 1996, Bogan (1997) captured 5 species at Ben Site. We captured an additional 2 species this year (Table 2). The set

of species caught in a single night often represented a majority of, but not the complete set of species captured at that site (Table 1). These data and comparisons demonstrate two points: 1) the high degree of variability between nights at a single site, and 2) the value of repeated netting in identifying all species that may use a location.

At several sites, a single bat species (*Antrozous pallidus*, *Eptesicus fuscus*, *T. brasiliensis*, or *Myotis volans*) constituted a very high proportion of the captures (56-100%) in one night. For example, on 29 June 99, 42 of 45 bats captured at Ridner tank were *T. brasiliensis*. However, this predominance of a single species at some sites was not necessarily consistent between nights. For example, 13 bats of only one species, *M. volans*, were captured at Val-Kil on 24 August 1999. However, on the previous net date, 28 bats of 7 species were caught.

*Analysis by bat species*

Of the 12 species captured, species caught in the highest numbers (> 60 bats) include *T. brasiliensis*, *A. pallidus*, *E. fuscus*, and *M. volans* (Table 3). Species caught in moderate numbers (30-59) include *M. thysanodes* and *Pipistrellus hesperus*. Species caught in low numbers (0-29) were *Corynorhinus townsendii*, *M. ciliolabrum*, *M. californicus*, *Lasiurus cinereus*, *Lasionycteris noctivagans*, and *E. maculatum*. *A. pallidus*, *T. brasiliensis*, and *P. hesperus* were caught at the most sites (n= 9, 8, and 7 sites, respectively), and *L. noctivagans* and *Euderma maculatum* at the fewest (n = 2 sites) (Table 3). Although *P. hesperus* was not caught in large numbers, this species was caught the most frequently (i.e. on the most nights of netting). *M. thysanodes*, *M. volans*, and *A. pallidus* were the next most frequently captured species (Table 3). Although suitable habitat seems to exist on WSMR for *M. evotis*, WSMR is at the edge of this species' range and *M. evotis* has not yet been documented on the range.

The number of bats captured of each sex and age are listed in Table 4. The high capture numbers and/or high percentages of reproductive females of *P. hesperus*, *A. pallidus*, *T. brasiliensis*, and *M. californicus* are consistent with values expected for these low elevation species (Tables 4 & 5). Significantly more female *T. brasiliensis* were captured than males (Table 4). Many of these females were caught at either Martin or Ridner tanks, suggesting the presence of maternity colonies in the local area.

The moderate to high number and percentage of reproductive female *E. fuscus* and *M. thysanodes* captured indicate that habitats surveyed are reasonably suitable for reproduction in these species (Tables 4 & 5). Although these species are typically found in woodlands and forests, they may be present and reproduce at lower elevations given suitable roost and water availability.

Significantly fewer female *M. volans* were caught than males (Table 4). Females were caught at only 2 of the 6 sites (Ben Site and Val-Kil) where this species was present, and reproductive females were captured at only Val-Kil. In addition, 90% of the females caught were nonreproductive (Table 5). These data suggest that habitats surveyed on WSMR are not particularly suitable for reproduction by *M. volans*, a Species of Concern.

Low capture numbers of *L. noctivagans* and *L. cinereus* at various elevations are not unusual, and the presence of only males of these species during the summer is typical. Because females have rarely been captured in New Mexico, female *L. noctivagans* are presumed to migrate northward and out-of-state to reproduce (Findley et al. 1975). Male *L. noctivagans* can be found in many vegetation types, but are more commonly found at higher mountain elevations. Accordingly, only 2 male *L. noctivagans* were captured during the early summer. Similarly female *L. cinereus* migrate north and eastward to reproduce (Findley and Jones 1964), and most captures in New Mexico are typically males. As expected, we captured only males and a nonreproductive female *L. cinereus*. Two juvenile *L. cinereus* (1 male and 1 female) were captured in late summer/early fall, presumably migrating southward.

Two captures of *E. maculatum* at Borrego and Mound Springs indicate the presence of this Species of Concern on WSMR. The audible calls of *E. maculatum* were also heard at additional sites. Research is currently finding that this species is often more abundant than mist net samples would indicate and that this species prefers roosting in high cliffs and rock faces (Easterla 1970, Watkins 1977, Leonard and Fenton 1983). Based on the abundant cliff roost opportunities at WSMR, this Species of Concern is likely more abundant on WSMR than mist netting efforts show.

The range of dates when reproductive females and juveniles for each species were caught are listed in Table 6. Netting began on 9 June 1999. Across species, most females with palpable fetuses were captured from 10 June to 30 June 1999. However, pregnant *T. brasiliensis* were captured as late as 26 July 1999. Because palpation of the abdomen is most effective at identifying fairly developed fetuses, dates reported here represent females in late stages of pregnancy. Across all species, lactating females were captured from 26 June to 7 September 1999. Postlactating females were captured from 12 July to 8 September 1999. Volant juveniles were caught in nets from 12 July to the last net date of 10 September 1999.

**Roost Identification**

Radiotransmitters were applied in sets of 2-4 at approximately 2 week intervals at selected net sites (Table 5). Twelve radiotransmitters were applied over the course of five radiotracking sessions from 30 June to 2 September 1999. Species of Concern were preferentially radiotagged relative to other species. Immediately after their release (around 0000 to 0200), bats were tracked to determine their direction of departure. On the subsequent 7-10 days, the field crew searched day and night in areas up to 7 miles away from the release site by road and on foot. Because road access was very limited, most high peaks had to be reached on foot. We radiotracked at night to locate bats as they emerged from their roosts, to identify their general vicinity, and to confirm that their radios were still functioning. Nine roosts were located for 6 radiotagged bats (Table 7). These roosts, including at least one colony, were located in rocks, cliffs, and manmade buildings.

*M. ciliolabrum roosts*

A lactating *M. ciliolabrum* (radio 78) radiotagged at Martin Tank was found approximately 4 miles east in a west-facing cliff on the south end of the Mockingbird Mountains. Field personnel could not get higher than 50-100 yards below the roost area; thus the exact roost location in the rock face could not be determined. The bat remained in this roost for at least 4 days.

A second lactating *M. ciliolabrum* (radio 53) was located in an east-facing cliff in Bear Den Canyon approximately 2 miles east of where it was radiotagged (Hardin Tank). Once again, the

exact location in the rock face could not be determined due to terrain. The bat moved from this location the next day and could not be relocated.

*M. thysanodes roosts*

A lactating *M. thysanodes* (radio 52) radiotagged at Hardin Tank was located 5 days after release approximately 1 mile west of the net site in the locked shed of a ranch just outside of Engle gate. Owners of the ranch and shed could not be contacted. Thus, we never gained access to the shed to inspect it or permission to observe it at dusk.

The day after its release, a lactating *M. thysanodes* (radio 94) radiotagged at Hardin Tank was located in a vertical crevice within an 8 foot tall pile of rocks approximately 2-1/2 miles north of Hardin. The next day, the bat had moved into a colony roost in the ceiling of the Wood Ranch house, which is approximately 3 miles northeast of Hardin. Bats inhabited the house and the shed behind it. At least 130 bats (and likely more) exited the house from several locations. Because of the many exits available from the house, the tendency of the bats to fly in and out at dusk, and difficult lighting conditions, an accurate exit count was difficult to achieve. More than one colony and more than one species may have used the Wood Ranch buildings. Two days later, the radio fell off the bat during its nighttime feeding and was recovered from the ground. During a postseason daytime inspection of this roost (on 8 Sept 99), I found the main house to be empty, but found two bats in the basement (an adult female *M. ciliolabrum* and a *C. townsendii* of unknown sex).

*M. volans roosts*

Three cliff roosts were identified for a nonreproductive *M. volans* (radio 96) radiotagged at Val-Kil tank in the Oscura mountains. The three roosts were in the west-facing cliffs of the escarpment just below the ridge. The first and third roosts were within a mile of the net site, near Bug and Atom Peaks, respectively. The second roost was approximately 6 miles south of Val-Kil along the escarpment, near Oscura Peak. The cliffs were too steep for field personnel to identify the exact locations of these roosts and too distant to observe from afar at dusk. Eight days after release, the radiotransmitter was recovered from the ground near the top of Workman

Ridge.

A postlactating *M. volans* (radio 93) radiotagged at Val-Kil was located 7 days after release in the cliffs at the south end of the Oscura mountain escarpment near Aerial Cable. Road and area closures at Aerial Cable prevented us from accessing and radiotracking in this area until 7 days past release of the bat. This roost was closer to the bottom of the escarpment and was approached from the base. But once again, field personnel could not climb high enough to locate the exact position of the roost within the cliffs.

*Other roosts found*

At dawn on 25 August 1999, I observed a small myotis (*M. californicus* or *M. ciliolabrum*) settle into its day roost in building 33200 at the Laser facility at North Oscura Peak (NOP). The bat's roost was in the crevice between the building and its roof gutter. No other bats were observed.

On 10 September 1999, we inspected the main cavern of Craven Cave and offshoots from the main cavern that were reasonably accessible. We found a relatively fresh pile of large-sized guano at the cave entrance which was likely from a night-roosting colony of *E. fuscus* or *A. pallidus* . We did not see any live bats during this daytime search or find evidence (guano piles) of former colonies. However, the distinct odor of guano emanating from within the offshoots suggests that bats may be using remote parts of the cave that cannot be accessed and visually inspected. The dried bodies of 2 *M. thysanodes* juveniles were found in separate locations within the cave, indicating that this species has used the cavern as a maternity roost. To determine if this cave is actively used by maternity colonies, by how many, and by which species, the cave should be exit counted and netted during the summer.

*Assessment of roost availability*

A variety of landscape features on WSMR can serve as maternity roosts. Such features include rocks, cliffs, manmade structures, trees, caves, mines, and lava beds. Rocks and cliffs are certainly in abundance and were the primary structure type used by radiotagged female *M. ciliolabrum* and *M. volans* this summer. Other species that may use rocks and cliff faces include

*M. californicus*, *M. thysanodes*, *M. volans*, *P. hesperus*, *A. pallidus*, and *E. maculatum* (Quay 1948, Vaughan and O'Shea 1976, Leonard and Fenton 1983, Schmidly 1991, Cryan 1997). To better manage maternity roost habitats, it is necessary to understand what structures are preferred and why (particular structural and thermal characteristics). Radiotelemetry is a relatively unbiased method for identifying types of structures used as roosts. Follow-up surveys can then be conducted to identify why a particular tree, cave, etc. was selected. However, the inaccessibility of many rock and cliff roosts makes them difficult or impossible to evaluate and characterize in a detailed manner. Fortunately, rock and cliff faces are in abundance and are less likely to be impacted by human activities than other roost types on WSMR.

Lava beds on WSMR, particularly lava tubes and other similar spaces, may provide roosting opportunities for bats as well. Identifying roosts in this structure type would be difficult by ground searching, but may be possible using radiotelemetry. General bat activity over lava beds can be evaluated using acoustical monitoring. No roosts were located this summer in the lava beds, but this is not surprising because bats were not radiotagged at water sources near the beds. Nonetheless, maternity roosts in lava beds (if there are any) are less likely to be impacted by human activities than other roost types.

Caves often serve as excellent maternity roosts, provided the thermal and structural characteristics are appropriate. Species captured on WSMR that commonly use caves and mines include *T. brasiliensis*, *C. townsendii*, and *M. thysanodes* (Kunz and Martin 1982, Wilkins 1989, Schmidly 1991). No cave maternity roosts were found using radiotelemetry this summer. Due to the limited number of caves and mines on the range, the most effective way to identify active cave roosts is through nighttime observation of each cave or mine. Craven Cave was a historical colony roost, but past exploitation and disturbance of the cave may have caused the colonies to relocate elsewhere or deeper within the cavern.

Manmade structures often serve as maternity roosts for several species of bats, including *M. thysanodes*, *M. californicus*, *E. fuscus*, *C. townsendii*, *T. brasiliensis*, and *A. pallidus* (Kunz and Martin 1982, Hermanson and O'Shea 1983, Brigham and Fenton 1986, Wilkins 1989, Schmidly

1991). These structures on WSMR range from old homesteads and associated buildings to barracks and other more contemporary buildings, are scattered around the range, and are often in very isolated locations. As long as water and suitable foraging areas are located within a reasonable distance (which varies with species), bats can easily colonize a suitable building. The Woods Ranch homestead was 2.5 miles from the nearest water, but served as a roost for *M. thysanodes*, *M. ciliolabrum*, and *C. townsendii* (and perhaps other species). An unnamed ranch house along RR 5 north of Woods Ranch also had evidence of light to moderate bat use. But Miller's Ranch and a number of other unnamed homesteads had no sign of bat use. For management purposes, homesteads on WSMR that are occupied by maternity roosts should be identified and protected from disturbance or destruction. To determine why certain old homesteads are used, additional occupied buildings must be identified and compared to unoccupied buildings. The most efficient method to identify occupied structures would be to physically search and inspect all known homesteads and historic buildings.

Military buildings and associated structures may also be used as roosts. The use of an external crevice on building 33200 at NOP by a solitary bat is one example of the use of these structures by bats. WSMR personnel relayed to us their nighttime observations of bats flying around NOP buildings. These bats may have been feeding, flying around their roosts, or both. Because newer buildings are usually sealed and more structurally intact, opportunities for large colony roosts may be fewer than in older, dilapidated structures. A survey of personnel at active facilities may help identify roosts in or around actively used buildings, and follow-up nighttime observations may confirm the presence of roosts. Because roosts in buildings and other manmade structures are highly susceptible to disturbance or destruction, they should be identified and managed accordingly.

Lastly, trees, shrubs, and other vegetation may provide roost opportunities to reproductive females on WSMR. Although none of the roosts located by radiotelemetry this summer were in trees, the number of roosts found this summer was small, and it would be premature to conclude that trees and vegetation are not used. Recently, more bat species have been found to use trees as maternity roosts (Barclay and Brigham 1995). However, most of these studies have been

conducted in forested habitats and at higher elevations. In pinyon-juniper woodlands on the Cibola National Forest, I have found *M. volans*, *M. thysanodes*, *M. evotis*, and *M. ciliolabrum* roosting in pinyon snags and junipers (unpublished data). *L. noctivagans*, *L. cinereus, E. fuscus* and *M. californicus* also use various types of trees (Schmidly 1991). On WSMR, pinyon-juniper woodlands provide potential roosting habitat in the Oscuras, the San Andres, and throughout various other mountain ranges. In the Oscura mountains, large stands of old growth pinyon-juniper woodlands are found adjacent to the site where four *M. volans* were radiotagged this summer. The fact that we did not find any roosts in these old growth stands is not surprising because many of these stands appear too dense and cluttered for bats to fly in. Although we did not locate any tree roosts this season, radiotelemetry remains the best method for locating maternity roosts in vegetation. The widespread availability of this roost type (relative to caves, mines, and buildings) make physical searches time-consuming and inefficient. Because trees and other vegetation are not as permanent, resilient, or sheltered as other roost types (e.g. caves, mines, buildings, rock, etc.), bats using these structures as roosts are more vulnerable to disturbance and are required to change locations periodically (as trees die or bark falls off) [Lewis 1995]. Because these roost types can easily be impacted by land management activities, it is important to identify whether trees and vegetation are used as maternity roosts (and if so, which species and why) and to protect these roosts from disturbance, destruction, and loss.

*Obstacles in radiotracking*

Although a targeted search of commonly used structures is a quick and inexpensive method of identifying roosts, the method is biased (i.e. surveys are based on a specific search image - caves, mines, buildings, etc.) and therefore cannot be used to identify the full range of structures used by bats as roosts. Radiotelemetry allows us to find roosts in expected as well as unexpected locations and thus permits us to better characterize the roost behavior and preferences of a species. Thus, we used radiotelemetry to study the roost habits and requirements of federal Species of Concern on WSMR.

Several factors interfered with our success radiotracking, and thus, we had difficulty relocating the bats. First, complications related to working on the range had a major impact on our ability

to track the bats. Missions, blocked roads, and restricted access made it difficult or impossible almost every radiotracking session to conduct searches on days following release, to reach good listening points, to approach suspected roost areas, or to listen at night when signals were more likely to be heard. Second, characteristics of the bats, the radiotransmitters, and the terrain made signals difficult to find. Signals from radiotransmitters in cliffs, caves, or underground may be dampened, directionalized (i.e. signal only emits in a very narrow beam), or blocked completely by rock or soil. Many of the bats never relocated may have been using rock or other roost types from which any emitted signal could not be detected by ground-based telemetry. Rugged terrain, steep cliff faces, and limited road access limited the amount of area that could be searched by the field crew each day and interfered with their ability to reach the roosts.

For radiotracking to be more successful on WSMR in future seasons, an additional budget for aerial telemetry should be allocated. In situations when ground tracking proves inefficient, such as this season, aerial telemetry can improve the chances of hearing radiosignals (fewer obstructions) and increase the area that can be searched. Aerial observers can identify the general vicinity of roosts on topographic maps, thus allowing ground-based telemetry efforts to be focused on pinpointing the exact roost location. Aerial telemetry has been proven highly effective in locating cliff roosts of bats in the Jemez mountains (M. Bogan, pers. comm.).

## Concluding Remarks

In field season 1999, we collected valuable distribution and roost data and laid the groundwork for future bat-related studies on the range. We located many good sites for netting bats and determined the 1999 distributions, sex ratios, and reproductive schedules for various species at sites throughout the range. We located roosts of 3 species (*M. volans*, *M. ciliolabrum*, and *M. thysanodes*) in two types of structures (buildings and rocks/cliffs) and worked out logistical problems associated with radiotelemetry work on the range. Work performed this season will serve as a useful reference and should enhance the productivity and value of future research on bat species distribution and roost use on White Sands Missile Range.

Natural extensions of this season's pilot research on bats include additional species sampling and continued efforts in identifying maternity roosts. To further clarify composition and dynamics of the bat community on WSMR, a minimum of one to two additional seasons of widespread and repeated netting is required. A comparison of data between years will provide a more complete view of species composition and distribution and a better understanding of the temporal and spatial variation in distribution, reproductive timing, and other parameters.

To identify important bat roosts and types of structures that need protection, two approaches, targeted searches and radiotelemetry, are recommended. Targeted searches of buildings, caves, and mines will identify major bat colonies that need protection from disturbance. Additional radiotelemetry will clarify the roosting habits and requirements of each species by identifying colonies in less obvious locations (than caves, mines, etc.) and in more ubiquitous roost types (e.g. trees, rocks, lava, etc.). Due to the rocky terrain, large amount of roadless area, relatively long distances traveled by the bats, and mission-related time constraints, it is strongly recommend that future telemetry studies have aerial support to increase the probability of relocating radios and to optimize the use of available resources (time, manpower, etc.).

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**Table 1.** Numbers of species and bats captured by site and date on White Sands Missile Range. In parenthesis by the site name is the cumulative number of bat species captured at that site.

| Site | Date | # captures | # species |
|---|---|---|---|
| Ben Site (7) | 06/27/1999 | 28 | 7 |
| | 09/07/1999 | 33 | 7 |
| Borrego Spring (5) | 06/11/1999 | 12 | 5 |
| | 09/05/1999 | 0 | 0 |
| Hardin Tank (9) | 06/24/1999 | 24 | 7 |
| | 07/13/1999 | 25 | 7 |
| | 08/04/1999 | 5 | 3 |
| Malpais Spring (2) | 06/21/1999 | 6 | 2 |
| Martin Tank (8) | 06/10/1999 | 27 | 6 |
| | 06/30/1999 | 64 | 8 |
| | 09/09/1999 | 0 | 0 |
| Mound Springs (5) | 07/26/1999 | 6 | 3 |
| | 09/10/1999 | 6 | 3 |
| Moya Tank (0) | 08/11/1999 | 0 | 0 |
| Rhodes Spring (9) | 06/25/1999 | 43 | 7 |
| | 07/12/1999 | 41 | 8 |
| Ridner Tank (4) | 06/29/1999 | 46 | 4 |
| Rock House (8) | 06/26/1999 | 41 | 8 |
| | 09/08/1999 | 12 | 6 |
| Val-Kil (7) | 08/16/1999 | 28 | 7 |
| | 08/24/1999 | 13 | 1 |
| Windy Tank (0) | 06/09/1999 | 0 | 0 |

**Table 2.** Number of each species captured by site at White Sands Missile Range in 1999. Species abbreviations are listed below. '#' indicates additional species captured at this site by Brozka (1991). '*' indicates species captured at this site by Bogan (1997).

| Site | Anpa | Coto | Epfu | Euma | Lano | Laci | Myca | Myci | Mycc | Myth | Myve | Myvo | Pihe | Tabr | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ben Site | 13* | 2* | | | | | 5* | 3* | 1 | 14 | | 17 | 6* | | **61** |
| Borrego Spring | 2 | | | 1 | 1 | | | | 4 | | | | | 4 | **12** |
| Hardin Tank | 2 | 3 | 7 | | | | 2 | 8 | | 19 | | 9 | 3 | 1 | **54** |
| Malpais Spring | # | # | | | | # | # | 1 | | # | | | # | 5 | **6** |
| Martin Tank | 46 | | 1 | | | | 1 | 1 | 4 | 5 | | 3 | 2 | 28 | **91** |
| Mound Springs | 3 | | | 1 | | 2 | | | | | | | 2 | 4 | **12** |
| Moya Tank | | | | | | | | | | | | | | | **0** |
| Rhodes Spring | 4 | 9 | 40 | | | 1 | 3 | 1 | | 4 | # | 8 | 14 | | **84** |
| Ridner Tank | 1 | | 2 | | | | | | | | | | 1 | 42 | **46** |
| Rock House | 12 | 1 | 14 | | 1 | | 2 | | 3 | 10 | | 7 | 3 | | **53** |
| Val Kil | 6 | | 1 | | | 3 | | | | 1 | | 18 | 1 | 11 | **41** |
| Windy Tank | | | | | | | | | | | | | | | **0** |

Species abbreviations: Anpa = *A. pallidus*, Coto = *C. townsendii*, Epfu = *E. fuscus*, Euma = *E. maculatum*, Lano = *L. noctivagans*, Laci = *L. cinereus*, Myca = *M. californicus*, Myci = *M. ciliolabrum*, Mycc = *M. californicus or M. ciliolabrum*, Myth = *M. thysanodes*, Myvo = *M. volans*, Pihe = *P. hesperus*, Tabr = *T. brasiliensis*.

**Table 3.** Total captures and the number of sites and nights a species was captured in summer 1999 on White Sands Missile Range. Species are in order by decreasing number of captures. 'SOC' indicates federal Species of Concern.

| Species | # captures | # sites | # nights |
|---|---|---|---|
| *Tadarida brasiliensis* | 95 | 7 | 9 |
| *Antrozous pallidus* | 89 | 9 | 12 |
| *Eptesicus fuscus* | 65 | 6 | 9 |
| *Myotis volans*[SOC] | 62 | 6 | 12 |
| *Myotis thysanodes*[SOC] | 53 | 6 | 12 |
| *Pipistrellus hesperus* | 31 | 8 | 13 |
| *Corynorhinus townsendii*[SOC] | 15 | 4 | 8 |
| *Myotis ciliolabrum*[SOC] | 14 | 5 | 6 |
| *Myotis californicus* | 13 | 5 | 8 |
| *Myotis californicus/ciliolabrum*[a] | 12 | 4 | 4 |
| *Lasiurus cinereus* | 6 | 3 | 3 |
| *Lasionycteris noctivagans* | 2 | 2 | 2 |
| *Euderma maculatum*[SOC] | 2 | 2 | 2 |

[a] This category includes individuals that could not be distinguished as one of the two species.

**Table 4.** Age and sex of bats captured on White Sands Missile Range in 1999. 'SOC' indicates federal Species of Concern. '**' indicates that sex ratio of captures is significantly different from equal at $P < 0.05$.

| | Adult | | % Adult F | Juvenile | |
|---|---|---|---|---|---|
| Species | F | M | | F | M |
| *A. pallidus* | 44 | 41 | .52 | 1 | 3 |
| *C. townsendii*[SOC] | 9 | 5 | .64 | 1 | 0 |
| *E. fuscus* | 27 | 38 | .42 | 0 | 0 |
| *E. maculatum*[SOC] | 1 | 1 | .50 | 0 | 0 |
| *L. noctivagans* | 0 | 2 | 0 | 0 | 0 |
| *L. cinereus* | 1 | 2 | .33 | 1 | 1 |
| *M. californicus* | 8 | 5 | .62 | 0 | 0 |
| *M. ciliolabrum*[SOC] | 8 | 6 | .57 | 0 | 0 |
| *M. thysanodes*[SOC] | 27 | 23 | .54 | 2 | 1 |
| *M. volans*[SOC] | 19 | 43 | .31** | 0 | 0 |
| *P. hesperus* | 11 | 18 | .38 | 2 | 1 |
| *T. brasiliensis* | 71 | 18 | .80** | 2 | 4 |

**Table 5.** Percentage of females captured in different reproductive stages on White Sands Missile Range in 1999. 'SOC' indicates federal Species of Concern.

| | % of total female captures | | | |
|---|---|---|---|---|
| Species | Pregnant | Lactating | Postlactating | Nonrepro |
| *A. pallidus* | 11 | 61 | 7 | 21 |
| *C. townsendii*[SOC] | 0 | 33 | 11 | 56 |
| *E. fuscus* | 48 | 11 | 0 | 41 |
| *E. maculatum*[SOC] | 0 | 100 | 0 | 0 |
| *L. noctivagans* | - | - | - | - |
| *L. cinereus* | 0 | 0 | 0 | 100 |
| *M. californicus* | 0 | 50 | 12 | 38 |
| *M. ciliolabrum*[SOC] | 25 | 25 | 0 | 50 |
| *M. thysanodes*[SOC] | 15 | 41 | 0 | 44 |
| *M. volans*[SOC] | 0 | 5 | 5 | 90 |
| *P. hesperus* | 9 | 46 | 18 | 18 |
| *T. brasiliensis* | 41 | 31 | 3 | 24 |

**Table 6.** Capture dates for reproductive females and juveniles in 1999 on White Sands Missile Range, NM. 'SOC' indicates federal Species of Concern.

| Species | Pregnant | Lactating | Postlactating | Juvenile |
|---|---|---|---|---|
| *A. pallidus* | 6/10-6/30 | 6/26-7/13 | 8/16-9/8 | 9/7-9/10 |
| *C. townsendii*[SOC] | - | 7/12-7/13 | 7/12 | 7/12 |
| *E. fuscus* | 6/25-6/26 | 6/26-7/12 | | - |
| *E. maculatum*[SOC] | - | 7/26 | | - |
| *L. noctivagans* | - | - | | - |
| *L. cinereus* | - | - | | 8/16-9/10 |
| *M. californicus* | - | 6/27-6/30 | 9/8 | - |
| *M. ciliolabrum*[SOC] | 6/24 | 6/30-7/13 | | - |
| *M. thysanodes*[SOC] | 6/10-6/27 | 7/13-9/7 | | 9/7 |
| *M. volans*[SOC] | - | 8/24 | 8/24 | - |
| *P. hesperus* | 6/26 | 6/27-7/26 | 7/12-7/26 | 8/16-9/8 |
| *T. brasiliensis* | 6/11-7/26 | 6/29-8/16 | 8/16 | 8/4-8/16 |

**Table 7.** Capture site and date, species and reproductive status of radiotagged female bats and roosts found on White Sands Missile Range in 1999.

| Site | Date | Radio # | Species | Repro. status[a] | Wt (g) | Roosts located | Roost #1 [(Type[b]) T, R, Sec] | Roost #2 | Roost#3 |
|---|---|---|---|---|---|---|---|---|---|
| Martin Tank | 06/30/99 | 74 | *M. californicus* | L | 5.2 | 0 | | | |
| | | 78 | *M. ciliolabrum* | L | 6.0 | 1 | (C) T9S, R4E, S36 | | |
| Hardin Tank | 07/13/99 | 87 | *C. townsendii* | L | 9.7 | 0 | | | |
| | | 52 | *M. thysanodes* | L | 9.9 | 1 | (M) T12S, R2E, S28 | | |
| | | 88 | *M. thysanodes* | L | 9.0 | 0 | | | |
| | | 53 | *M. ciliolabrum* | L | 6.2 | 1 | (C) T12S, R2E, S25 | | |
| Hardin Tank | 08/04/99 | 94 | *M. thysanodes* | L | 10.0 | 2 | (R) T12S, R2E, S11 | (M) T12S, R2E, S13 | |
| | | 92 | *M. thysanodes* | L | 9.4 | 0 | | | |
| Val-Kil | 08/16/99 | 96 | *M. volans* | N | 7.5 | 3 | (C) T7S, R6E, S06 | (C) T8S, R5E, S12 | (C) T6S, R5E, S36 |
| | | 95 | *M. volans* | N | 8.5 | 0 | | | |
| Val-Kil | 08/24/99 | 13 | *M. volans* | L | 8.1 | 0 | | | |
| | | 93 | *M. volans* | O | 9.0 | 1 | (C) T8S, R5E, S12 | | |

[a] Reproductive status: L = lactating. O = post-lactating. N = nonreproductive.

[b] Roost types: R = rock. C = cliff. M = manmade building.

**Appendix A.** Descriptions of water sites surveyed on White Sands Missile Range in 1999. Names of sites that were netted for bats are preceded with astericks. Township, range, and section information is in brackets after the name. Sites that we arbitrarily named are in single quotations.

*** 'Windy' Tank [T5S, R6E, S17]:** This dirt stock tank is north of the WSMR boundary. Tank is in an open, mildly hilly valley between two ridges. The surrounding area is sparsely wooded with juniper. This tank is very large (~ 250 ft. by 120 ft.), deep, has steep sides, and held water all summer. Because of the water depth and steep sides, only the periphery can be netted. *Directions: Along Hwy 380 at 1.9 miles east of Bingham, turn south down a dirt road and travel 1.3 mi. Tank is on west side immediately adjacent to the road.*

*** Borrego Spring [T5S,R6E,S32]:** Borrego Spring is also north of the WSMR boundary. This site consists of two dirt tanks, one of which is approximately 60 ft. by 50 ft. The surrounding area is grassy with large junipers. Some areas of the two tanks are full of vegetation. On 3 June 1999, the tanks had 1-2 ft. of water. *Directions: At 1.9 miles east of Bingham on Hwy 380, turn south down a dirt road and travel ~4.5 miles. Tank is just past an intersection with a dirt road.*

**Chicken Spring [T6S, R6E, S28]:** On 7 June 1999, this site consisted of a series of puddles choked with vegetation and brush. Puddles were <5" deep. Site was unsuitable for netting. *Directions: From Hunter's Lodge gate, follow RR 9 south approx. 3.5 miles. Turn west onto dirt road and follow for approx. 1.2 miles. Turn south at crumbling building and black tank. Continue approx. 2.4 miles to Chicken spring.*

**Rabbit Spring [T6S, R6E, S20]:** On 7 June 1999, this site consisted of a series of puddles choked with vegetation and brush. Puddles were <5" deep. Site was unsuitable for netting. *Directions: From Hunter's Lodge gate (on Hwy 380, 25.7 miles east of Stallion Gate turnoff), follow RR 9 south approx. 3.5 miles. Turn west onto dirt road and follow for approx. 1.2 miles. Turn south at crumbling building and black tank. Continue approx. 2.4 miles to Chicken spring. Rabbit spring is west of Chicken Spring.*

**Brush Tank [T6S, R6E, S26]:** This is a dirt tank that was dry on 7 June 1999. On 11 August 1999, water was 2 ft. deep, but tank was mucky and had very little open water. *Directions: From Hunter's Lodge gate, follow RR 9 south approx. 4.8(?) miles. Turn east onto small dirt road to tank.*

**Unnamed [T7S, R6E, S24]:** On 7 June 1999, this large dirt tank (~ 60 x 60yds) was dry. Surrounding vegetation was desert scrub.

*** 'Val-Kil' [T7S, R6E, S06]:** On 11 August 1999, the dirt tanks 'Val' and 'Kil' had approx. 1-2 ft. of water and measured 70 ft. by 50 ft and 60 ft. By 40 ft., respectively. 'Val' tank is the northern of the two tanks. There are some brush and sticks in the tanks. Surrounding area is pinyon-juniper. *Directions: From Hunter's Lodge gate, continue south approx. 7.6 miles to intersection with RR 331. Continue west on RR 331 approx. 3 miles. Just past 'Val test site'*

*sign, these two tanks are visible on the south side of the road. A small dirt road just prior to the intersection of RR 331 and RR 332 bisects the two tanks.*

*** Moya Tank [T7S,R6E,S03]:** On 11 August 1999, this dirt tank was approx. 1.5 ft. and roughly 60 ft. by 90 ft. in dimensions. This tank was filled with flowering vegetation and dry sticks that protruded just above the surface. Edges of the tank were marshy. This tank had slightly more open water than Brush tank. *Directions: From Hunter's Lodge gate, continue south for 7.4 miles. Moya tank is past the windmill, but before the Moya test site sign, on the east/north side of the road.*

**Cornet Tank [T6S, R4E, S01]:** On 8 June 1999, this large dirt tank was dry. *Directions: From Stallion Gate, travel south along RR 7 for approx. 1.7 miles. Turn east onto RR 24. At approx. 8.3 miles along RR 24, turn north onto dirt road (RR 3621?). At approx. 1.9 miles, Cornet is east of the road on the other side of an arroyo.*

**Trail Canyon [T7S, R5E, S01]:** On 8 June 1999, this open-topped, steel-rimmed tank was full at 10 ft. deep. Although this site may be an excellent water source for bats, it requires a specialized net setup because of its height. *Directions: From Stallion Gate, travel south along RR 7 for approx. 1.7 miles. Turn east onto RR 24. At approx. 8.3 miles along RR 24, RR 24 intersects with RR 3621 and turns into RR 13. From this intersection, continue SE along RR 13 for 3.6 miles. Just past the sign for 'Beck', turn east on a dirt track. Continue for 9.4 miles to Trail Canyon tank.*

**'Crow' Tank [T7S, R6E, S05]:** On 19 August 1999, this dirt tank had < 6" water and was approx. 15 yd. by 20 yd. in dimensions. Dampness outside the existing water's edge suggested the tank had been at least 20 yd. by 30 yd. when full. Tank was very marshy and mucky. *Directions: From Hunter's Lodge gate, continue south approx. 7.6 miles to intersection with RR 331. Continue west on RR 331. Approximately 1 mile east of Val-Kil tanks, on the south wide of the road is 'Crow' tank.*

**'Craven' Tank [T7S, R8E, S20]:** On 11 August and 10 September 1999, this tank was only 2-3" deep, but ~ 45 ft. wide. There was much algae growing, and red-spotted toads were emerging from the mud. Surrounding area is desert scrub. *Directions: Less than 1 mile south of northern intersection of RR 9 and RR 337 is a dirt road heading due east. Follow this dirt road for 6.7 miles to RR 11. Continue north on RR 11 for approx. 1.8 miles to fork. RR 11 veers right at fork (going straight takes you to entrance of Red Rio bombing range). Continue past this fork 2.8 miles to an obscure 2 track heading south. (This road is just west of a small north-south oriented line of hills). At 1.4 miles south along this dirt road is 'Craven' tank.*

**Nabor Tank [T8S, R6E, S02]:** This dirt tank was dry on 11 April 1999 and measured approx. 60 ft. by 80 ft. in dimensions. Surrounding area is creosote, mesquite, and grassland. *Directions: From Hunter's Lodge gate, drive south on RR 9 approx. 14.4 miles to the northern intersection of RR 9 and RR 337. Turn west onto RR 337. Continue on 337 for approx. 6.4 miles to dirt tank just past some old corals.*

*** Ben Site [T9S, R5E, S15]:** This 20 ft wide, windmill-fed, steel tank is located 200 yards north of (behind ) the Ben Site buildings. On 3 June 1999, water was 4-5 ft. deep. On 7 September 1999, water was only 1 ft. deep because the pipes had sprung a leak. Surrounding area has junipers, mesquite, saltbush and other desert scrub. *Directions: Ben Site is on the north side of RR 7 just west of the intersection of RR 7 and RR 12.*

**Red Tank [T9S, R6E, S30]:** On 1 April 1999, this wide, shallow, dirt tank was approx. 1-2 ft. deep and had little vegetation growing in it. On 8 June 1999, the tank was dry. *Directions: From the western intersection of RR 9 and RR 12, travel west on RR 12 for approx. 4.3 miles to a raised dirt road on the south side of the road. Turn south and follow 0.2 miles to Red tank.*

*** Martin Tank [T9S, R4E, S31]:** This dirt tank was approx. 2-3 ft. deep and 60 ft. by 60 ft. in dimensions on 4 June 1999. The sides are moderately inclined. On 9 September 1999, depth had increased to >5 ft and dimensions were larger. In June, much wildlife visited this tank at dusk. Surrounding area is desert scrub. *Directions: From Stallion Gate, drive RR 7 south for 23.5 miles to intersection with RR 13. Follow RR 13 south for 9.5 miles. Obscure, dirt track on east side of road leads approx. 50 yards to Martin tank.*

**Ladder Tank [T10S, R4E, S18]:** At this site on 4 June 1999, mounded earthen sides surrounded a series of large puddles with <1 ft. water. On 17 June 1999, the tank was dry. On 23 August 1999 after some summer storms, the tank was 2-3 ft. deep. On 9 September 1999, the tank was almost dry again. Immediately surrounding the tank are several medium to large tamarisk. Surrounding vegetation is desert scrub. *Directions: From Stallion Gate, drive RR 7 south for 23.5 miles to intersection with RR 13. Follow RR 13 south for 13.1 miles. On east side of road is Ladder tank.*

**'E. Ladder' Tank [T10S, R4E, S22]:** This dirt tank is surrounded on all but the south side with dense tamarisk growth. The north end is thick with aquatic vegetation. On 4 June 1999, the tank was roughly 60 ft. by 90 ft. and a maximum of 4 ft. deep. On 30 June 1999, the tank was dry. On 6 July 1999, the tank had water again. *Directions: Find dirt road just south of Ladder tank. Follow small dirt road east for approx. 3.6 miles to 'E. Ladder'.*

**'Far E. Ladder' Tank [T10S, R4E, S12]:** This large dirt tank is south of the road and built into a hill. There are old ranch remains (fence, old building, etc.) to the east of the tank. On 4 June 1999, this tank was dry and full of tamarisk and grass. *Directions: Find dirt road just south of Ladder tank. Follow small dirt road east for approx. 3.6 miles to 'E. Ladder'. Continue past 'E. Ladder' for ?? miles to the next dirt tank which is on the south side and 2 arroyos distant from the road.*

*** Mound Springs:** This site consists of two separate spring-fed pools of water contained within raised mounds of earth and is surrounded by a metal fence. The smaller of the pools is surrounded completely by dense tamarisk. The larger of the pools has much vegetation lining the edges, but is easily accessible from the road side. On 8 June 1999, water was 3-5' deep. The large pool is curved. The long dimension is roughly 120 ft. The width varies from 20 ft. to 50 ft. This site is full probably year-round. The surrounding area is desert scrub. *Directions: From*

*western intersection of RR 9 and RR 12, drive south on RR 9. At approx. 4.5-4.8 miles, look for dirt road on west side of road. Turn west onto road which drives out to Mound spring.*

*** Malpais Spring [T12S, R6E, S08]:** This site is a saline wetland. Water is widespread and less than 1 ft. in depth. Grasses and sedges predominate in vegetation. *Directions: From western intersection of RR 9 and RR 12, drive south on RR 9. Continue for approx. 15.6 miles to reach Malpais springs on south/west side of road.*

*** Hardin Tank [T12S, R2E, S27]:** These two, steel-rimmed stock tanks varied in depth from 1.5-2.5 ft. throughout summer. The larger tank is approx. 17 ft. diameter. Sides of the tanks are approx. 2.5 ft. tall. *Directions: From Rhodes Canyon Range Center, follow RR 6 west for 17 miles to RR 5. Turn north on RR 5 for approx. 0.7 miles to Hardin Ranch house. Tanks are in corral next to house. From T or C, find Hwy 52 to town of Engle. When you enter Engle, cross the railroad tracks and turn left (north) at the intersection. Main road will curve right and follow power lines going east. Continue east on Route 52 past turnoffs for several ranches until you approach a final ranch just outside the Engle gate. Must go through gated fence before reaching WSMR gate (Engle gate).*

*** Rhodes Spring [T13S, R2E, S12]:** This tank is approx. 2 ft. deep and 25 ft. wide and was full all summer. The edges of the tank are thick with vegetation. Some aquatic vegetation near the tank overflow. Surrounding vegetation includes pinyon-juniper, mesquite, and other shrubs. *Directions: From Rhodes Canyon Range Center, follow RR 6 west for 14.5 miles. Tank is on south side of road in canyon at bottom of a steep slope.*

*** Rock House [T13S, R2E, S12]:** This shallow, spring-fed tank has brick sides and was roughly 1 ft. deep throughout the summer. Dimensions are roughly 15 ft. by 15 ft.. Tank is surrounded by grasses and cattails. General area has scattered mesquite, juniper, and tamarisk. A moderately steep slope climbs from the south side of the tank. *Directions: From Rhodes Canyon Range Center, follow RR 6 west for approx. 13.5 miles. Tanks is on the south side of the road in the canyon at bottom of a steep slope and next to a dry creek bed.*

*** Ridner Tank:** This large dirt tank is surrounded by mesquite densely on one side, and is more open on the other. On 1 April 1999 and 11 June 1999, the tank was approximately 2.5-5 ft. deep and approx. 120 ft. wide. *Directions: From Rhodes Canyon Range Center, travel south on RR 7 to RR 305. Head west on RR 305 approx. 2.5 miles. An obscure dirt road on north side of road leads to cluster of large mesquite surrounding tank.*